DECLARATION

I, Steven D. Roberts of Access Europe

do hereby declare that I am conversant with the English and French languages and am a competent translator thereof.

I declare further that the following is a true and accurate translation into English of the French Patent Application N° 04 50221 filed on 06/02/2004.

Signed this 15TH Day of April 2009

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1 NATURE OF THE APPLICATION			
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2 TITLE OF THE INVENTION			
	METHOD AND MACHINE FOR PRODUCING THREE-DIMENSIONAL OBJECTS BY DEPOSITING SUCCESSIVE LAYERS		
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6 ATTACHED DOCUMENTS AND FILES	Electronic file	Pages	Details
Text of the Patent	textebrevet.pdf	18	D 13, C 4, AB 1
Drawings	dessins.pdf	5	page 5, figures 7, Abstract: page 2, Fig. 2
Designation of inventors			

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6 ATTACHED DOCUMENTS AND FILES	Electronic file	Pages	Details
Text of the Patent Drawings Designation of inventors	textebrevet.pdf dessins.pdf	18 5	D 13, C 4, AB 1 page 5, figures 7, Abstract: page 2, Fig. 2

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062 Filing	EURO	0.00	1.00	0.00
063 Search report (S.R.)	EURO	320.00	1.00	320.00
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Number of applicants	2
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TITLE OF THE INVENTION

METHOD AND MACHINE FOR PRODUCING THREE-DIMENSIONAL OBJECTS BY DEPOSITING SUCCESSIVE LAYERS

DOCUMENTS SENT

package-data.xml	Requetefr.PDF	fee-sheet.xml
Design.PDF	ValidLog.PDF	textebrevet.pdf
FR-office-specific-info.xml	application-body.xml	request.xml
dessins.pdf	indication-bio-deposit.xml	

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METHOD AND MACHINE FOR PRODUCING THREE-DIMENSIONAL OBJECTS BY DEPOSITING SUCCESSIVE LAYERS

DESCRIPTION

Field of the invention

The invention pertains to the production of objects in three dimensions by depositing successive layers, and more precisely to models. It therefore also concerns the area of « rapid prototyping ». It applies, *inter alia*, to the manufacture of models requiring high construction accuracy such as models for jeweler, spectacles, electronic packaging, aeronautics.

Prior art and problem raised

In the area of jeweler, it is known to produce models in three directions using so-called "rapid prototyping" systems. One type of these systems is based on placing heat-fusible material on a work platform, mobile along a vertical axis. This type of process consists of depositing a high number of successive layers, of constant or different thickness, whose successive surface areas correspond to the gradual forming, along a vertical axis, of the model to be produced. It is therefore necessary to define a large number of sections of the object to be produced by making successive slices of parallel planes,

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the distance between each section corresponding to the thickness of one layer. To reconstitute the object or model, the sections are stacked in sequence one on top of the other. It is to be noted that it is also known to use computer-aided design or digitizing tools to implement said process.

Depending upon methods, the materials used may be heat-setting liquids such as liquid resins or heat fusible materials such as waxes. It is noted that a shaving operation on each deposited layer is performed to calibrate the thickness and regularize the upper surface. A multitude of layers are thereby deposited on the preceding layer.

For the model production of objects of very sophisticated shapes, it is known in the jeweler industry to produce a model by means of a large number of two series of successive layers, each consisting of different materials. One first material is used to form the final part, a second to form its support. The support material is removed by dissolving in a bath once the deposit and solidification of the successive layers are completed.

Also, with reference to figure 1, from European patent EP 0 715 573, a device is known for making three-dimensional models by the sequential formation of a multitude of layers one upon the other by drop depositing a modeling material. This device comprises:

- a platform 1 for the model to be produced, mobile along a vertical axis;
- a first main carriage 3A mobile along a longitudinal axis, giving support to a secondary carriage 3B mobile along an axis transverse to the preceding axis;
- two jets 2 depositing drops of the two materials one after the other, attached to the secondary carriage 3B;
- a third "loose" carriage 3C mobile along the longitudinal axis of the main carriage 3A, on which the shaver 3D is arranged intended to surface the layers produced, driven episodically after the depositing of each layer via action of the main carriage 3A;
- control means managing the positions of the mobile assemblies along the vertical, longitudinal and transversal axes, and the timed ejection of drops of materials.

The making of models using this type of device, depositing the two types of materials one after the other, is relatively long, namely several hours and even several days. There is therefore a need to accelerate the manufacture of this type of model.

The purpose of the invention is therefore to propose a method and a machine able to produce models quicker.

Summary of the invention

For this purpose, one first main object of the invention is a method for producing three-dimensional objects by forming a large number of successive parallel layers, along a first direction, each consisting of two heat-fusible modeling materials. The method using the two following main steps:

- a first step consisting of the timed supply of a first modeling material to at least a first jet positioned on a first fixed work station, and of moving the jet over the surface of a support platform along second and third directions perpendicular to the first direction and along a determined pathway, to place drops of material on the support surface; and

- a second step consisting of conducting the same operation with at least one second jet positioned on a second fixed work station and supplied with a second material, along another determined pathway,

this cycle being renewed a sufficient number of times, with pathways determined in relation to the object, in order to construct the object.

According to the invention, since the platform consists of 2.N platforms on each of which the process is implemented, each of the 2.N platforms is alternately moved under a number N of fixed work stations each having at least one first jet to perform the first step, then under a same number N of fixed work stations each having at least

one second jet to conduct the second step, in order simultaneously to achieve 2.N deposits of material on the 2.N platforms, each platform remaining separate from the other with respect to its mobility along a vertical direction.

Preferably after every second operation, surface shaving of the deposited layer is performed under a fixed shaving station with at least one shaver mounted rotatably about a fixed axis perpendicular to the first direction.

A second main object of the invention is therefore a machine to produce three—dimensional objects by forming a large number of successive, parallel layers along a first direction, each consisting of two modeling materials, on a supporting surface and by means of two jets each supplied with a different material at fixed work stations, and mobile relative to a main carriage along a second direction perpendicular to the first direction, the main carriage being mobile with respect to the fixed depositing station along a third direction perpendicular to the first direction, this machine implementing the steps of the above-mentioned method.

According to the invention, 2.N fixed work stations are used, the supporting surface consists of 2.N platforms on each of which the process is simultaneously conducted, the 2.N platforms being moved at the same time and alternately under a number N of first

fixed work stations each carrying at least one first jet, by means of the mobile secondary carriage mobile to implement the first step, and under a same number N of second fixed work stations each carrying at least one second jet, by means of a mobile secondary carriage to implement the second step, in order simultaneously to produce 2.N objects.

Preferably, use is also made of a number N of fixed surface shaving stations positioned every second fixed work station between two adjacent work stations.

The main embodiment of the invention provides that the supporting surface is mounted rotatably about a main axis parallel to the first direction, the 2.N platforms being spaced apart at an angle to each other by an angle pitch of π/N, the 2.N fixed work stations also being spaced apart at an angle of π/N.

One particular embodiment of the inventive machine provides that N = 1, the angle pitch being 180°, the fixed shaver station being offset by 90° with respect to the fixed work stations.

In this latter embodiment, the supporting surface is advantageously carried by a crossbar mounted rotatably about the main axis and carrying the two opposite platforms.

This assembly is advantageously completed by the use of an angle encoder positioned at the base of the crossbar.

This crossbar can advantageously be driven in rotation by an electric motor and a wheel/worm screw driving system.

The main and secondary carriages are advantageously driven by linear motors.

List of figures

The invention and its different embodiments and advantages will be better described in the following description accompanied by several figures, respectively illustrating:

- figure 1, a prior art device for producing a three-dimensional model;
- figure 2 is an aerial view of a preferred embodiment of the inventive machine;
- figures 3A, 3B and 3C are three different views of the embodiment in figure 2;
- figure 4 is a variant of this same embodiment; and
- figure 5 schematically illustrates a possible further development of the inventive machine.

Detailed description of two embodiments of the invention

With reference to figure 2, a preferred embodiment of the inventive machine provides that on a frame 10 of the machine, two work platforms 11 are mounted. These platforms are pivot mounted about a main vertical axis A, so that they can rotate about this axis and take up position alternately under two work stations symbolized by the two groups of tooling shown.

More precisely, a crossbar 20 forming a carrier structure is pivot mounted about the main axis A.

An encoder 21 is located underneath the crossbar 20, so as to be able to command its rotation about the main axis A. This crossbar 20 carries two supports 12 themselves each bearing a work platform 11. The two supports 12 are mounted mobile in vertical translation, parallel to the main axis A by means of two respective guide screws 17 and each driven by a motor 16. This movement allows progressive lowering of each of the platforms 11 after the depositing of a layer, during the manufacturing process of each object.

On each of these platforms 11, an object is therefore to be constructed by depositing numerous successive layers of two heat-fusible materials, by means of two jets 12 each positioned on a

fixed depositing station arranged diametrically opposite one another.

The latter consist of a pair of parallel rails 18 on which a main carriage 14 is mounted mobile in horizontal translation. The movements of this carriage therefore follow a second direction perpendicular to the first direction symbolized by the main axis A which is vertical. On each of the main carriages 14 a secondary carriage 13 is mounted mobile in translation and carrying a jet 12. Each secondary carriage 13 is therefore mobile in horizontal translation along a third direction perpendicular to the second direction schematized by the main carriages 14. The three directions of movement mentioned are materialized in figures 2, 3A, 3B and 3C by three orthogonal axes Ox, Oy and Oz. The respective carriages 13 and 14 may be driven by conventional mechanical systems of belt pulley or stepping motor type, but in the illustrated figure they are directly driven by linear motors 19A thereby eliminating any positioning errors due to wear of the components of conventional mechanical transmission systems. With the use of linear motors, movements are controlled by linear encoders 19B.

It is therefore easy to understand that each jet 12 can be moved over a surface parallel to its respective platform 11 located below it, along the second and third directions, so

fixed depositing station arranged diametrically opposite one another.

The latter consist of a pair of parallel rails 18 on which a main carriage 14 is mounted mobile in horizontal translation. The movements of this carriage therefore follow a second direction perpendicular to the first direction symbolized by the main axis A which is vertical. On each of the main carriages 14 a secondary carriage 13 is mounted mobile in translation and carrying a jet 12. Each secondary carriage 13 is therefore mobile in horizontal translation along a third direction perpendicular to the second direction schematized by the main carriages 14. The three directions of movement mentioned are materialized in figures 2, 3A, 3B and 3C by three orthogonal axes Ox, Oy and Oz. The respective carriages 13 and 14 may be driven by conventional mechanical systems of belt pulley or stepping motor type, but in the illustrated figure they are directly driven by linear motors 19A thereby eliminating any positioning errors due to wear of the components of conventional mechanical transmission systems. With the use of linear motors, movements are controlled by linear encoders.

It is therefore easy to understand that each jet 12 can be moved over a surface parallel to its respective platform 11 located below it, along the second and third directions, so

the position of the platforms 11 in work position. In this figure 3C, the fixed work stations are schematized by the two jets 12.

Figure 4 shows a variant of embodiment of this machine in that, instead of a single shaver 25 as shown in the preceding figures, two shavers 25A and 25B are provided. These are positioned alongside each other to perform a surface shaving operation in two depth passes. It can be contemplated for example that the pass depth provided for a surface shaving operation is too deep to be made by a single shaver for a given material. The two shavers 25A and 25B are then positioned at different heights corresponding to the depth of the pass made by the first shaver. It is to be noted that the number of shavers is not limited to two as in the example illustrated in figure 4.

With reference to figure 5, the number of platforms 11 can be an even number, greater than 2. In other words the number of platforms used following the inventive principle is 2.N. It is therefore possible to manufacture 2.N objects or models at the same time. Figure 5 shows six platforms 11 (2.N where N = 3) offset at an angle of 60° from one another (π/N where N = 3). Conjointly three shavers 25 have been positioned offset from each other at an angle of 120°, each positioned between two

groups of two adjacent platforms 11. It can therefore be generally understood that after two operations to deposit successive layers at two fixed work stations, surface shaving can be performed.

The two embodiments described in this description are based on a machine comprising a crossbar that is rotatably mounted and supports 2.N platforms, the machine frame comprising a number 2.N of fixed work stations. It is possible to consider that the platforms 11 could be moved via conveying devices over a closed continuous pathway, irrespective of the form of the pathway.

It can therefore be easily understood that with the inventive machine and method, it is possible to fabricate a number 2.N of objects simultaneously in a time equivalent to the fabrication time of one object with a prior art machine such as described with reference to figure 1.

CLAIMS

1. A method for producing three-dimensional objects by forming a large number of successive parallel layers in a first dimension and each consisting of two heat-fusible modeling materials, the method using the two following main steps:

- a first step consisting of the timed supply of a first modeling material to at least a first jet (12) positioned on a first fixed working station, and of moving the jet with respect to the supporting surface along second and third directions perpendicular to the first direction and over a determined pathway, to deposit drops of material on the supporting surface; and

- a second step consisting of conducting the same operation with a second jet positioned on a second fixed work station and supplied with a second material over a determined pathway,

this cycle being renewed a sufficient number of times, with pathways determined in relation to the object, in order to construct the object,

characterized in that the number of fixed work stations is 2.N, the supporting surface consists of 2.N platforms (11) on each of which the process is implemented, each of the two 2.N platforms (11) is alternately moved to lie under at least one of the N first jets (12) to conduct the first step, then under at least one of the N second jets (12) to

conduct the second step, in order to deposit simultaneously 2.N deposits of material on the 2.N platforms (11).

2. The method as in claim 1, characterized in that surface shaving of the last deposited layer is performed after every second operation under a fixed shaving station with at least one shaver (25, 25A, 25B) mounted rotatably about a fixed axis perpendicular to the first direction.

3. A machine for producing three-dimensional models by forming a large number of successive, parallel layers along a first direction and each formed of two modeling materials on a supporting surface by means of at least jets (12) each supplied with one of the two materials at fixed work stations, and mobile with respect to a main carriage (14) along a second direction perpendicular to the first direction, the main carriage (14) being mobile with respect to the fixed depositing station along a third direction perpendicular to the first direction, this machine implementing the steps of the method according to claim 1, characterized in that the supporting surface consists of 2.N platforms (11) on each of which the process is implemented simultaneously, the 2.N platforms (11) being moved at the same time and alternately under a number N of first depositing stations each carrying a first jet (12), by means of a mobile secondary carriage (13) to implement the first step, and under a same number N of

second fixed depositing stations each carrying a second jet (12) by means of a mobile secondary carriage, to implement the second step in order to produce 2.N objects simultaneously.

4. The machine as in claim 3, characterized in that it comprises a number N of fixed surface shaving stations, positioned every second fixed depositing station between two adjacent depositing stations.

5. The machine as in claim 3, characterized in that the supporting surface is mounted rotatably about a main axis (A) parallel to the first direction, the 2.N platforms (11) being spaced at an angle from each other by an angle pitch of π/N, the 2.N depositing stations also being positioned at an angle of π/N.

6. The machine as in claim 5, characterized in that the number N equals 1, the angle pitch is 180°, the fixed shaving stations being offset by 90° with respect to the two fixed work stations.

7. The machine as in claim 6, characterized in that the supporting surface is carried by a crossbar (20) mounted rotatably about the main axis (A) and carrying two opposite platforms (11).

8. The machine as in claim 7, characterized in that it comprises an angle encoder (21) located at the base of the crossbar (20).

9. The machine as in claim 8, characterized in that the crossbar

(20) is driven by a motor (22) and a wheel/worm screw driving system (23).

10. The machine as in claim 3, characterized in that the main (13) and secondary (14) carriages are driven by linear motors.

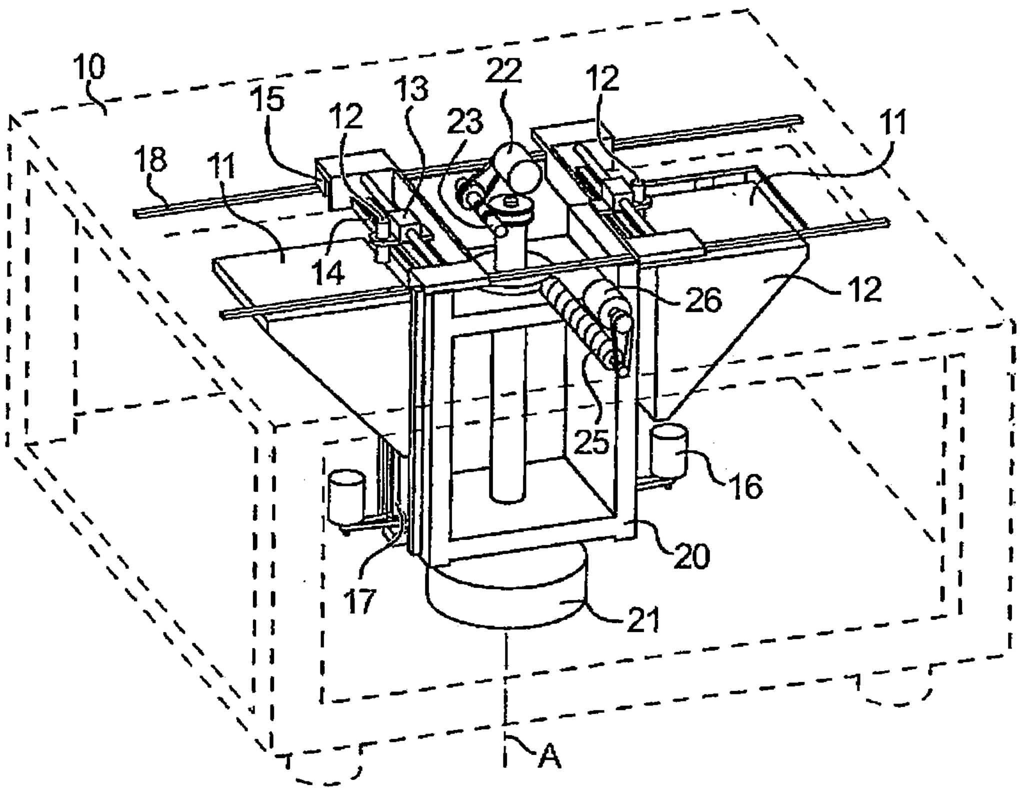

FIG. 2

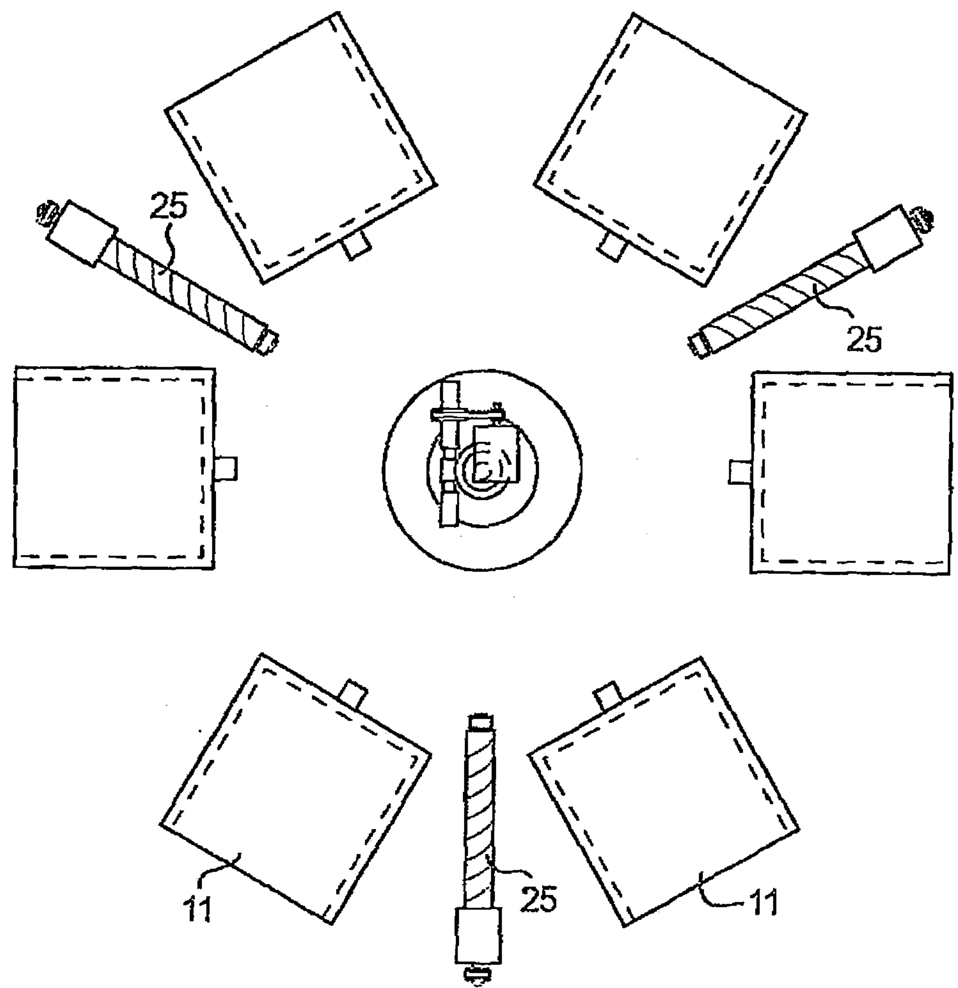

FIG. 5

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Designation of the Inventor

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TITLE OF THE INVENTION	
	METHOD AND MACHINE FOR PRODUCING THREE-DIMENSIONAL OBJECTS BY DEPOSITING SUCCESSIVE LAYERS
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